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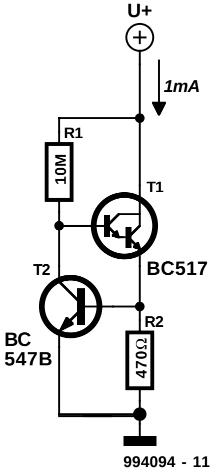
simple constant-current source



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The simplest version of a constant-current source, which we often use for that reason, consists of only a FET with the source and gate connected together. This utilizes the zero-gate-voltage drain current (I_{DSS}) of the FET. Sometimes a source resistor is added to allow the current level to be set more exactly.

A disadvantage of such a very simple current source is that the maximum drain-source voltage of most standard FETs is no more than 30 to 40 V. If we look at bipolar transistors instead, the range of available voltages is significantly larger. This is adequate justification for developing an alternative current source, using bipolar transistors, that is comparably simple.

In the example shown here, we use a BC547 and a small Darlington transistor (BC517). For convenience, we have chosen a current of 1 mA for calculating component values. Transistor T2 controls the current, and resistor R1 determines the base-emitter voltage of T2. R1 also provides the base current for T1, but the value of R1 can be made high since T1 is a high-gain Darlington transistor. The advantage of this is that the resulting error in the current setting is very small. If the value of R1 is 10 MΩ, the base-emitter voltage of T2 is less than 0.5 V, so that a current of around 1 mA flows through the current source when R2 is 470 Ω.

The current regulation that a constant-current source must provide comes from the fact that T2 controls the base current of T1. This means that if the current through R2 should increase, the base current of T1 would be reduced since the collector current of T2 would increase. If we assume that the amplification factor of T2 is at least 10,000, then the value of R1 must be at least 10 MΩ to produce a voltage drop of 1 V. The error current through R1 is thus negligible in comparison to the total current.

Since the current through R1 varies with the applied voltage, the base-emitter voltage of T2 will also vary. A disadvantage of this is that the internal resistance of the current source is reduced. In addition, the temperature dependence of T2 shows up fully in the output current. For a number of applications, this is however not that important. In fact, this characteristic could be used intentionally, for example to provide temperature compensation or for a particular measurement or control circuit.

In spite of its simplicity, this circuit in fact proved to be able to deliver a nice constant current. With the prototype, the measured current (at room temperature) was 0.91 mA with an input voltage of 5 V; this increased to 0.99 mA at 15 V, and a value of exactly 1.04 mA was measured with a 30 V input.

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